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ELEMENTARY NOTIONS OF SPACE AND TIME

By J. L. SYNGE

THE Theory of Relativity requires such a complete revision of ideas which have subconsciously acquired the status of obvious truths, that it is well worth our while to consider carefully some points of an apparently elementary nature, bearing on the most fundamental topics of physical theory, namely, space and time. Such considerations, together with an account of some of the conclusions of Einstein, form the subject of my remarks: I leave aside altogether the reasoning by which the conclusions are reached, believing such reasoning capable of expression only in mathematical form.

We shall speak of experiments, simple of description, yet quite impracticable. These we may call ideal experiments. As a laboratory for these experiments it would be unwise to choose one of our ordinary terrestrial laboratories, for on the earth the physics of space and time is complicated by gravitation and the rotation of the earth. Let us construct in imagination an immense room of glass, situated in the void far from the earth, sun, and other gravitating bodies. We shall suppose if an astronomer in this ideal laboratory fixes his telescope on a star, that the image of the star remains permanently on the cross-wires of the telescope: in other words, the laboratory has no rotation relative to the stars.

If any defence of such a fanciful picture is needed, we must remember that it is just by such acts of imagination that scientific

thought progresses. In discussing the elementary problem of the simple pendulum, it is tacitly assumed that the experiment is conducted under ideal conditions, for the rotation of the earth makes the problem much more complex, as was so well proved experimentally by Foucault. Here, as in the cases we are about to discuss, the ideal results are a first approximation to those actually obtained, and by adding complexities step by step we arrive at conditions approaching more and more closely to actuality.

Let us now inquire what physical meaning is to be attached to the word *straight*. If a line is drawn on the floor of the laboratory, what test should be applied to it to determine whether it is straight or not? There are four principal tests, the lines satisfying which may be called respectively

(1) the *rotational* line,
(2) the *shortest* line,
(3) the *optical* line,
(4) the *inertial* line,

and associated respectively with four great names, Euclid, Archimedes, Plato and Newton. If we have a line traced on a rigid bar and wish to determine whether it is a rotational line, we mark two points, A and B, on the line, cut the bar along the line into two parts, and holding one part fixed rotate the other about A and B. If throughout the whole process of rotation the two cut edges remain in coincidence, then we say that the line given by either of the cut edges is a rotational line. The shortest line is determined by the form of a tightly-stretched string, the optical line by a light ray, and the inertial line is the path of a free particle. There is no *a priori* reason why these four types of line should coincide in every instance with one another; nevertheless physicists of all schools are prepared to adopt the hypothesis of their coincidence in the ideal laboratory mentioned above, which is remote from gravitating matter. Thus, under these circumstances, we have lines which may fitly be termed *straight*, since they satisfy all four tests. This hypothesis is a natural one to make, for were the four types of line not coincident, it would almost inevitably follow that there existed certain principal or privileged directions whose existence in a region remote from the influence of all matter would be extremely improbable. With the addition of the further

hypothesis that the geometry of the ideal laboratory is Euclidean, we complete the description of the spatial relationships in the absence of gravitation.

To study the effect of a field of gravitation, let us imagine a circular hole cut in the floor of the laboratory. Into this hole there is introduced a massive sphere whose centre is made to lie in the plane of the floor. Following the General Theory of Relativity, the immediate effect of this introduction is the breaking of the floor. This result is a deduction from the theorem that it is, in general, impossible to move a perfectly rigid body in a strong gravitational field, analogous to the fact that it is impossible to slide a piece of inextensible cloth over the surface of an ellipsoid with preservation of contact at all points of the cloth. It is important to note that the breaking of the floor obliterates the straight lines which, in the absence of gravitation, had been traced on the floor. The floor having been repaired, the four types of line must again be investigated *ab initio*.

As has been mentioned, movement of rigid bodies in a gravitational field is, in general, impossible; therefore the test for rotational lines is generally inapplicable. It is only for the special class of lines which radiate from the massive body, that the test can be applied. Application of the three remaining tests to these radiating rotational lines shows them to be also shortest, optical and inertial lines. Therefore, since all four tests are satisfied, these lines may be termed *straight* without ambiguity. But when we investigate the shortest, optical and inertial lines joining two points, A and B, which do not lie on the same radiating straight line, we

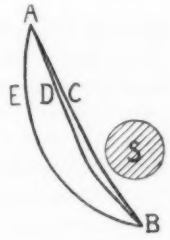

Fig. 1

no longer find agreement between the various types. In Fig. 1, ACB represents the shortest line, ADB the optical line, and AEB a typical inertial line, since there are, of course, an infinity of paths by which a particle can travel from A to B corresponding to an infinity of velocities of projection. We perceive at once that, except in the case of the radiating lines aforesaid, the word *straight* has no longer a definite meaning, and should not be used.

Seeing that we are primarily interested in the application of the theory to problems of astronomical dimensions, we shall not further consider the properties of shortest lines, but concern ourselves with the optical and inertial lines, representing respectively the paths of light-rays and of planets.

The cylinder of light-rays proceeding from a distant star and grazing the sun's surface will not converge to a focus if we accept the classical concepts of space and time and do not admit that light propagation is influenced by gravitation: if we accept the classical concepts but hypothesise that gravitation acts on light as though it were ordinary matter, the cylinder of rays converges

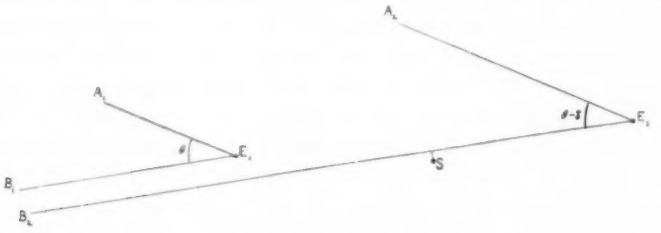

Fig. 2

to a focus as though the sun were a lens. With this result the Theory of Relativity is in qualitative agreement but predicts a focal length just one half that given by the classical theory. The rival predictions cannot, unfortunately, be put directly to the test since the shorter focal length is approximately 5×10^{10} miles. A less direct, but convincing test has been made in the Eclipse expeditions of 1919 and 1922, the results of observation confirming the theory of Einstein. It might be permissible, however, to offer a criticism of the mode of expression commonly employed. It is

customary to say that a light ray is *bent* in a gravitational field. Surely *bending* means, both popularly and scientifically, *deviating from a straight line*, and as has been pointed out there exists no straight line to constitute a criterion of deviation. It would be better, perhaps, to sacrifice brevity for clarity by the substitution of some fuller description. The prediction of Einstein does not involve any such intrinsic contradiction, and may be described with the assistance of Fig. 2. S represents the sun, E_1 a position of the earth and A_1E_1, B_1E_1 rays proceeding from stars A and B

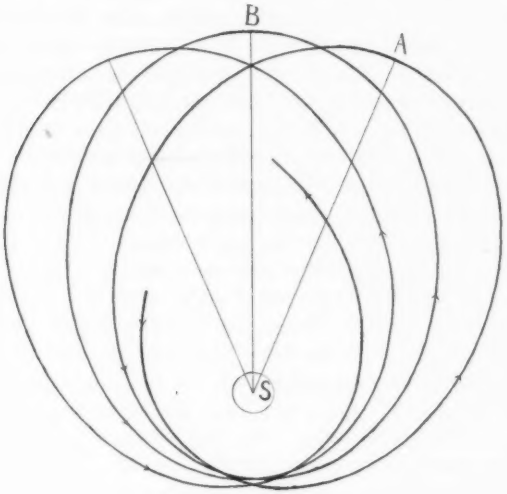

Fig. 3

(not shown), neither of these rays passing close to the sun; E_2 represents another position of the earth, A_2E_2, B_2E_2 rays proceeding from the same two stars, but in this case the ray B_2E_2 passes close to the sun, at a distance p from its centre. Let us denote by θ and $\theta-\delta$ the angles $A_1E_1B_1$ and $A_2E_2B_2$ respectively. The classical theory predicts δ to be either zero or $2m/p$ where m is the mass of the sun: Einstein predicts δ to be $4m/p$.

There yet remain for consideration the inertial lines or planet-paths. On the Newtonian Theory these are either simple closed

curves (ellipses) or infinite curves (hyperbolae and parabolae), the elliptical paths being of prime importance. A point on the path at which the distance from the sun attains a maximum is called *aphelion*. For an elliptical path the aphelion is a fixed point. Einstein predicts the planet path to be a curve of the type depicted in Fig. 3: there A and B denote two successive aphelia, and a characteristic of the path may be summarized in the statement that, during each revolution, the aphelion advances through a constant angle ASB. This affords an explanation of a formerly unexplained movement of the aphelion of the planet Mercury.

The discussion of time is more difficult than that of space, on account of prejudices which we are inclined to carry over from ordinary experience. There are three fundamental words, *before*, *after* and *simultaneous*, whose meanings are sufficiently clear for practical purposes but which require careful consideration before they can be admitted into precise physical discussion.

Let us imagine a weight suspended by a string, and underneath the weight a soft cushion. There is a screen which hides the string and weight from an observer but leaves the cushion visible. The string is cut with a pair of shears and the weight falls on the cushion. Two events occur: the snip of the shears and the contact of the weight with the cushion. Which event, in the judgment of the observer, occurred before the other? If he is at some distance he will, of course, *see* the weight fall on the cushion before he *hears* the click of the shears, and might, casually, be inclined to say that the weight fell before the shears cut, but a moment's consideration suffices to reverse this decision (without any knowledge of the laws of propagation of light and sound), because the snip of the shears *caused* the falling of the weight. The principle, of which the above is an illustration, may be enunciated as the Principle of Causation:

If an event A caused an event B, then A occurred before B.

Having thus attached a causal significance to the words *before* and *after*, we might rashly assume that the meaning of the word *simultaneous* was a direct consequence. The attendant difficulties may be illustrated as follows: Let us suppose that a physicist A reads a thermometer at a certain instant, and that another physicist B, situated at some distance from A, desires to read his own thermometer simultaneously. Let us see whether this can be achieved

without recourse to the customary machinery of time measurement and by means of the Principle of Causation alone. Let B despatch a messenger who reaches A just as the latter makes his reading, and returns immediately to B. Then B may be sure that if he had taken his reading when the messenger left he would have been before A, but if he had waited until the messenger returned he would have been after A. He has however no means of fixing a precise instant of simultaneity in the interval which elapses during the absence of the messenger. This interval we may call the "interval of doubt". The obvious remedy is to despatch swifter and swifter messengers, thus making the interval of doubt shorter and shorter. On the Newtonian theory there is no limit to the velocity of bodies, and thus the interval of doubt may be made arbitrarily small: in fact there will be only one instant common to all the intervals, and it may rationally be called the instant of simultaneity. Thus the classical theory gives a definition of simultaneity consequent on the Principle of Causation. Now physicists have never encountered bodies in nature having a relative velocity greater than that of light and Einstein denies the possibility of their existence. Thus in the above problem the most advantageous messenger is a light ray and the interval of its absence is the shortest interval of doubt obtainable: within this interval the instant of simultaneity cannot be fixed by the Principle of Causation. This abandonment of an absolute simultaneity constitutes the most important deviation of the new theory from the old.

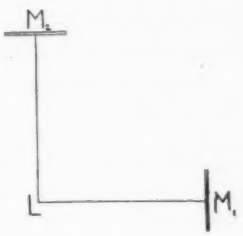

Fig. 4

Let us return to the ideal laboratory, from which the massive body has been removed so that there is no gravitational field. Let us place a lamp on the floor at L, and let M_1 and M_2 be two mirrors set up with their reflecting faces towards L, perpendicular to the floor, and perpendicular to the lines LM_1 and LM_2 respectively: let M_1LM_2 be a right angle and the lengths LM_1 and LM_2 equal to one another (Fig. 4). The lamp L is concealed from the mirrors by a shutter. At a certain instant this shutter is withdrawn

and rays of light travel along LM_1 and LM_2, are reflected by the mirrors and return to L. Which ray will return first or will they return simultaneously? It is to be noted that the simultaneity here considered concerns events occurring in the history of one object (the lamp L) and is regarded as a fundamental intuitive conception, unlike the simultaneity of events occurring in the histories of two different things, the case which we discussed earlier. As was pointed out in the discussion of spatial relations in the absence of gravitation, it is to be expected that the interior of the ideal laboratory is in every way isotropic, or in other words that any direction is equivalent to any other. The simultaneous return of the two light rays is a consequence of this isotropic character. Moreover if the experiment is conducted in a number of independent ideal laboratories, we should expect the same result in every case. The admission of this result constitutes a radical deviation from the classical idea of light propagation, and leads us mathematically to strange results regarding the behaviour of measuring rods and clocks in motion, which we shall consider later.

So far we have not spoken of the measurement of time. What instrument shall we adopt? Certainly not a crude and complicated mechanism of wheels and springs. Further, in the ideal laboratory, there is no apparent rotation of the heavens which gives us our terrestrial time. We shall adopt the light ray as the most suitable instrument for time measurement, and, recognizing this fact, it is not surprising that the velocity of light enters so largely into the formulae of Relativity. The light-clock is very simple. At the ends of a unit measuring rod mirrors are set up facing one another and perpendicular to the rod. If we pass a light between these mirrors, a ray will be caught between them and oscillate to and fro. The successive impacts of the ray on one of these mirrors mark off units of time there. With a number of such clocks distributed throughout the laboratory, we have a means of measuring time at any point. But how shall we synchronise these clocks? The following device is adopted. A certain clock is selected as master clock, and from it light rays are sent out in all directions. At a certain distant clock which we desire to synchronise with the master clock, these light rays are received and immediately returned. If one of these rays left the master clock at 3 and returned

at 5, then the distant clock must be set to read 4 at the instant when the ray arrived there. This number 4 is determined as the mean of the numbers 3 and 5. We further suppose that, when once synchronised, a clock will remain in synchronisation, and that two clocks synchronised with the master clock are synchronous with one another. These assumptions are natural, and need not detain us further. Thus we have throughout the laboratory a consistent system of clocks, and if an event occurs anywhere, it is only necessary to read the adjacent clock to obtain the time of the event. Thus we may speak of two events as being simultaneous if they occurred at the same time as recorded by their local clocks, but we have no reason to suppose that two events simultaneous with respect to the clock system of one laboratory are also simultaneous with respect to the clock system of another laboratory moving relatively to the first. We have abandoned the absolute simultaneity of Newton, based on causal relationships, and substituted therefor a relative simultaneity based on light propagation.

It is unfortunate that the Theory of Relativity should be exposed to the charge of irrationality on account of certain phrases unhappily worded. We have already seen that "the bending of a light ray" is not above reproach. What meaning is to be attached to the phrase: "A rigid body contracts when in motion"? Truly as the phrase stands, it is a manifest contradiction since a rigid body is one which neither contracts or expands. Nevertheless the sentence has a very real meaning as the following imaginary experience may make clear. Let us imagine that in our ideal laboratory there is a long straight canal through which a vessel is passing with a velocity approximately one-half that of light. The interior of the ship is then itself an ideal laboratory in the sense in which we have used that term: we shall therefore speak of the bank of the canal and of the ship in order to make it plain to which we refer. The two essential instruments of measurement are the rigid measuring rod and the light-clock; we may suppose the clocks fitted with dials to record the passage of time. Clocks are placed at short intervals along the canal bank and synchronised by the method described above. Let us suppose that there is a lock on the canal, and towards this lock the vessel is speeding. To pass on to a higher level it must come to rest in

the lock and moreover must be short enough to fit between the gates of the lock. We shall suppose the length of the lock to be 450 feet. A certain anxiety arises in the minds of the owner of the ship, situated on the bank, and the captain on the ship as to whether the vessel will fit within the lock. The captain measures the length directly with a measuring rod and determines it to be 500 feet, and thus regards it as useless to approach the lock. On the other hand the owner, whose operations are confined to the bank, carries out a more complicated system of measurement. At each of the clocks he stations a clerk with instructions to make two readings, first the time when the bow of the ship passes him, and secondly the time when the stern passes him. When the ship has gone by, the owner finds the clerk who records the passage of the bow at 3 o'clock, and also the clerk who records the passage of the stern at 3 o'clock. Then says the owner: "If the bow was here at 3 o'clock and the stern there *at the same time*, the length of the vessel must be the distance between these two points". Measurement of this length gives 435 feet. Which has estimated the length correctly, captain or owner? The lock provides the crucial test: when the ship comes to rest there it is found to be just 50 feet too long, thus establishing the correctness of the captain's measurement. The owner may however truthfully record that a ship in motion *apparently* contracts in length. We see that this apparent contraction involves, in the clock system, the question of light propagation.

There yet remain to be described the phenomena observable in the case of clock systems in relative motion. Let us suppose that on board the ship described above there is a standard light-clock, and that when the ship passes a clock on the bank which is reading zero, the clock on the ship is set to read zero also. Now if when the ship's clock records the passage of one unit of time, a man on the ship observes the clock on the bank which happens at that instant to be adjacent to the ship, he will find that the clock on the bank records the passage of more than one unit of time, although all the clocks in question are of identical construction.

University of Toronto.

ASTRONOMY A NATIONAL NECESSITY*

By R. J. McDiarmid

(Concluded from June issue)

As we pass along through the ages, we find ways and means of recording time gradually changing. The water clock, in its many forms, remained in use till the tenth century. The first clock made to run by weights was built by Gerbert at Madgeburg in 998. Later he became Pope Sylvester II. In 1288 the first public clock appeared in England at Westminster Hall, now part of the British House of Commons. A great discovery was made in 1581 by Galileo, when he was only 20 years old. He watched the swinging lamp in the Cathedral at Pisa and by one finger on his pulse found that although the lamp swung through ever-shortening spaces, yet it moved more slowly and so still swung in equal times. It was this idea that eventually led to the development of the pendulum clocks, the most accurate stationary clocks in use at the present time. The Dutch astronomer Huyghens was the first to put Galileo's discovery to use in the building of the pendulum clock in 1657.

Up to this time the art of navigation was in a very primitive state. It was confined chiefly to the Mediterranean sea and coasting from port to port within sight of land. The method of finding a ship's longitude at sea was the insufficient one of dead reckoning—that is the direction and speed of the ship were estimated as closely as possible from port of sailing and carried on from day to day. The uncertainty of the method was great and many sea disasters have been recorded as a result of this method of guess work. Explorers such as Christopher Columbus and Magellan plainly showed that the art of navigation was an asset in the lives of future nations.

If one were planning a trip to Europe or some distant land, China, India or Australia, they would first inquire about their

*Address given February 13th before Ottawa Centre, Royal Astronomical Society of Canada.

steamer, harbour of departure, and then book passage, never giving the matter further consideration. The day of departure they go aboard their boat with no misgivings as to reaching their destination. In fact never give it a thought, feel just as much at ease as on the railway train, which runs along its narrow track already laid for it, while their steamer goes forth to traverse for many days, often weeks, an ocean without a single fixed mark or indication of direction, and, furthermore, it is exposed to winds and currents which may turn it from its course. The art of navigation to a considerable degree has been made safe by the science of astronomy.

It is no doubt true that the mariner uses the magnetic compass, but unless he knows his position he does not know the compass bearing from the true north, with the result that he is in difficulties at once,—just as Columbus was in 1492 when approaching the shores of America. From observations made in Canada, the variation of the pointing of the compass needle is sixty degrees. Along the Atlantic coast the compass points thirty-five degrees to the west of true north, and at Vancouver on the Pacific coast twenty-five degrees to the east of true north. It is quite clear what difficulties the navigator would be in if he followed the pointing of the compass and did not know the variation from the true north. It was because of this variation that Columbus, when he was near the shores of America, had a mutiny of his sailors. The compass did not, as was previously supposed, point to the pole. Columbus got out of the difficulty gracefully and quieted his sailors by telling them that the stars had moved while the compass had remained stationary. It was in 1492 that the variation in compass pointing was first discovered, and, as it is continually changing, the mariner must know his position as well as the variation to be certain of his true compass pointing. Hence a ship's latitude and longitude must necessarily be known. Latitude is the distance measured in degrees north or south of the equator; while longitude is the difference in the local time between an initial meridian, such as Greenwich, and the vessel's position. The latitude can readily be determined by observing the greatest altitude of the pole star by night or the sun's greatest altitude by day, which occurs at noon. The difficulty in the case of the longitude was to know the local time at Greenwich when making the

observations at sea. Local time can always be obtained from the sun.

A brief outline of the founding of the Greenwich Observatory will show how the development of nautical science and that of fundamental astronomy went hand in hand. When Spain began her colonization in the new world, she realized the importance of navigation. In 1598 Philip III of Spain offered a prize of 100,000 crowns to any one who was able to determine the longitude of a ship at sea. Holland was interested in forming a closer connection with her colonies and she too offered a prize of 30,000 florins. Galileo, hearing of a toy made by a Dutch optician Jensen in 1590, was able to fashion his first telescope in 1610, and by its application to the heavens among other things he discovered that Jupiter had four satellites, which were eclipsed by the planet. He determined their periods and was able to determine when these eclipses for future times would occur for his station of observation. Galileo at once saw how this could be used to determine the longitude. The idea was simply this, the eclipses occur at the same time the world over, and as they are observed by the local time for the stations of observation, Galileo's record and that of observation was simply difference in local time or difference in longitude.

Later, when England and France sought supremacy of the seas in their colonial policy, the idea which developed in England, due to a Frenchman, Le Sieur de Saint Pierre, was to relate the moon to the stars and in that way get the Greenwich time. In short, the whole sky may be considered a vast clock set to Greenwich time, the stars the numbers on the dial face and the moon the hand moving among them. This was the method of lunar distances.

To find the longitude at sea therefore it was necessary to be able to predict precisely the different positions of the moon in the sky for any time throughout the year, and it was also necessary that the places of the stars should be very accurately known. When the method of "lunars" was presented to Charles II, King of England, he at once called on his scientific advisers, members of the Royal Society, to look into the matter. The Reverend John Flamsteed pronounced the method sound, but the positions of the stars and the motions of the moon were so inaccurately known that

its application would only result in disaster. It was therefore to gain a better knowledge of the motions of the moon and the positions of the stars that the Greenwich Observatory was founded and the nautical almanac instituted to convey this information to mariners in a correct form. Charles II appointed Flamsteed as His Majesty's Astronomer in 1675 and charged him to proceed with all diligence and care to accurately determine the positions of the fixed stars and observe the motions of the sun, moon and planets in order that the so much desired longitude at sea could be determined. The Greenwich Observatory was established as the need of the nation for the benefit of the navy and the general commerce of the realm. It was therefore the great desire on the part of Great Britain to navigate the seven seas with speed and safety that served as an impetus to fundamental astronomy. Flamsteed was appointed the first Astronomer Royal of Great Britain at a salary of 100 pounds sterling a year, about $485, 10% of which he paid into the exchequer as income tax, and furthermore he had to purchase his own instruments and pay assistants out of his private purse. Great credit and praise is due the first Astronomer Royal in his contribution to astronomy and navigation, as, at his death after forty years of labour, he had actually determined the positions of 2,925 stars, as well as corrected the motion of the moon, which enabled Sir Isaac Newton, his contemporary, to verify his law of gravitation.

The great contributions of the different heads of the Greenwich Observatory have been noteworthy in the development of astronomy and nautical science. In this connection it is of particular interest to refer to the prize of 20,000 pounds sterling offered in 1714 by the British Government for an accurate ship chronometer to aid in determining longitude at sea. The requirement placed on such a chronometer was that by its use a ship's longitude during an Atlantic voyage could be determined within half a degree, that is, it would keep Greenwich time correct to within two minutes in a voyage across the Atlantic. Halley, Flamsteed's successor, was active in promoting this particular work, and gave those making early attempts in building chronometers every assistance and encouragement. Halley was closely associated with Newton, and it was personally due to him that the great work, Newton's Principia,

was brought to light. Halley was the first to give actual proof that the stars have proper motion. It was Maskelyne, the fifth Astronomer Royal, that was called on in 1761 to carry out tests on Harrison's chronometer. Two years later, 1763, he made the voyage from Portsmouth to the Barbadoes in order to examine into the accuracy of this chronometer, and on his return to the Greenwich Observatory, 160 days later, it was found that there had been a variation of considerably less than two minutes. Harrison received the award. Maskelyne published the first Nautical Almanac for mariners about ninety years after the founding of the Greenwich Observatory, 1765. It is a great tribute to those early pioneers, who did so much in establishing Britain's supremacy as a naval and commercial power, to those who surveyed for hydrographic charts on the high seas, as well as the geographic surveys carried on by such explorers as Bruce, Livingstone and Stanley in other parts of the world, that Greenwich is not only the Initial Meridian for the bulk of the civilized world, but that Greenwich Mean Time increased or decreased by an exact number of hours or half-hours is the standard time all over the world.

We have seen that the Greenwich Observatory was established as a national need, not only to serve the navy, but for the commerce of the nation; so it was in the case of our national observatory at Ottawa, as it too was established as a necessity. In 1867, by the Act of Confederation, Canada came into being as an overseas Dominion of Great Britain. At that time it consisted of four provinces—Nova Scotia, New Brunswick, Quebec and Ontario. Four years later British Columbia joined the Dominion as a province, one of the conditions being that a railroad should be built through to the Pacific coast; for this British Columbia conveyed in trust of her Crown lands to the Dominion not to exceed twenty (20) miles on each side of the railway; this was known as the "railway belt" and became Dominion Lands.

In co-relating the railway belt with other surveys in the Northwest Territories, now provinces of Alberta and Saskatchewan, it was found necessary to accurately determine in longitude and latitude points along the railway line. The mountainous character of the country did not permit the survey being extended which was employed in the territories. The astronomical work was begun

in 1885, and as Canada at that time had no station established in longitude with reference to Greenwich, the Canadian astronomers used Seattle on the west coast of the United States (established from Washington and hence known with respect to Greenwich) as a base for the longitudes. Work was carried on for two years and in 1887 a request was made that an Observatory be established at Ottawa, seat of Government, and that it be used as a base for all Canadian work. The idea was persistently urged on the Government and in 1890 Canada's first Chief Astronomer, the late Dr. W. F. King, was appointed and likewise the Observatory came into existence. Two years later Montreal's longitude was established by cable with Greenwich. The growing need for geographical position was such that the Cliff St. Observatory in 1902 was replaced by the present Dominion Observatory with more modern equipment. Fifteen years later from it sprung the Astrophysical Observatory at Victoria, B.C., with its large telescope, the second largest reflector in the world. The Observatory at Ottawa is the base for all work that pertains to longitude in Canada. The Observatory was established as a national need, not only for the determination of longitudes but for carrying out definite lines of observation and investigations of a scientific character.

One of the main problems of astronomy is that which deals with the accurate determination of time. In determining such three essentials are necessary, a telescope, such as a meridian circle, a chronograph, *i.e.*, a recording device, and a reliable clock. The meridian circle telescope derives its name from the fact that it moves in the meridian plane. Such instruments are mounted with extreme care so that instrumental corrections such as level, azimuth and collimation are very small. This instrument can be used to determine time and also determine the positions of the stars in Right Ascension and Declination and other heavenly bodies. The stars in the heavens are all charted for position, the same as the ships at sea or points on the earth's surface. It has been before and since Flamsteed's time the task of the astronomer to determine the positions of these heavenly bodies, increase the precision and determine their motions, in order that navigators, surveyors and other astronomers can use their results to further the accuracy of their work.

Several countries publish annually Ephemerides and Nautical Almanacs, which contain, besides the positions of the sun, moon and planets, that of a great number of stars, whose positions are accurately known, and by their use it is possible for the astronomer to determine his time accurately with an error slightly greater than one-hundredth of a second of time. Hence, by making observations on all possible occasions, the rate of the clocks can be determined, and at a national observatory, on request, the correct time can be obtained.

One application is sufficient to show what is the real value of accurate time. The boundary line between Canada and Alaska, when Alaska belonged to Russia, was decided by the treaty of 1825 to be the 141st Meridian West of Greenwich. This meridian was never established. In 1867 United States bought Alaska from Russia for about seven million dollars, and about twenty years later Canada and United States decided, by mutual agreement, to establish this meridian. With this end in view the late Wm. Ogilvie, later Governor of the Yukon, was sent as Canada's representative and Mr. McGrath from the United States. At that time, 1886, there was no telegraphic communication with the north country, and they established the meridian by observing culminations of the moon. A few years later a dispute arose over the Alaska Boundary, which was settled in London in 1903, with the result it was felt desirable, since telegraphic communication was established, to re-determine this 141st Meridian by exchange of clock signals by telegraph. In 1907 Canada and United States, by mutual agreement, sent representatives to again determine this meridian. The result of the later determination differed by 350 feet from that previously established in '86. The agreement is very close when the two methods are compared. This fact bears out a former statement—of the importance of accurate determination of time. Just in this connection it is interesting to note that the longitude of Harvard Observatory, one of the first stations to be established on this continent in longitude with respect to Greenwich, was first established by moon culminations, and the use of several hundred chronometers transported from Greenwich at various times by ocean steamers. The earliest observations bear the date of 1769. After the laying of the Atlantic cable in 1866,

closer comparisons with the zero longitude of Greenwich were possible. The discrepancy between the two methods is about 320 feet.

With the advance of science along so many lines, such difficulties as the astronomers of '86 had to contend with are partly overcome at least. The transmission of clock signals by wireless is a great advance in the establishing of geographical positions in out of the way places, such as along the Mackenzie river near the Arctic ocean. The wireless transmission of the seconds signals of a clock is truly wonderful, but the accuracy of a determination of longitude even by that method depends on the accuracy with which these times are determined by the astronomer. Accurate time is one of the prime essentials in making gravity observations, as was done this last year along the Mackenzie river. In fact accurate time is an absolute necessity, not only in the scientific work of astronomy and other sciences, but in the more practical use of jewellers, and our railroads in their rapid transportation systems.

We have seen what a part astronomy played in the life of the Ancient Egyptian; to the Babylonian it furnished a means of measuring time, and eventually gave us our present system of units. As we pass through the ages we find the science of astronomy contributing much for the betterment of man's condition, namely, the safe navigation of the high seas, the compilation of tide tables, the rapid transportation by land, and in case of our Dominion, the fixing of our boundaries and the establishing of our meridians.

DOMINION OBSERVATORY, OTTAWA,
April 30th, 1923.

COMPARISON OF OBSERVATIONS OF ANNAPOLIS AND BORDEAUX WIRELESS TIME SIGNALS MADE AT OTTAWA AND GREENWICH (ENGLAND)*

By W. Bowyer

THE results of observations of the Annapolis and Bordeaux wireless time signals made at Ottawa and published in recent numbers of the Journal of the R.A.S. of Canada led to the comparison with similar observations made at Greenwich.

All the results have been obtained at Greenwich by the use of automatic registration of the signals. The system employed is one in which the wireless signal causes a valve, set on the verge of oscillation, to oscillate during the period of the signal. The change of anode current occurring during oscillation causes a very sensitive electro-mechanical relay to close a local circuit which includes the coil of a syphon recorder of low sensitivity. The recorder tapes are scaled by the seconds' beats of the standard clock. The contact springs operating at the escape of the clock are made to close a tuned buzzer circuit in the receiving room. This signal is picked up by the receiving set as a wireless signal and passes through to the recorder in the same way as an incoming wireless signal.

The points of interest from the comparisons are:

(1) The close agreement of the differences between the 1st and 300th signals of the Bordeaux series on any day, as observed at Ottawa and Greenwich. The difference is generally 0.00s. or 0.01s., with a few of 0.02s., the mean being 0.008s.

(2) The Ottawa and Greenwich clock errors compared viâ Annapolis or Bordeaux show a satisfactory agreement. There are a few cases where the discordances amount to about 0.10s. but in general the differences are about 0.02s.

(3) The differences in the clock comparisons shown in the second abstract are distributed among the time determinations of the several observatories. The errors arising from comparison by means of wireless signals are much smaller quantities.

The differences, Greenwich minus Ottawa, by Bordeaux signals, would be increased by 0.02s. by correcting the Ottawa sidereal times for time of transmission of the Bordeaux signals.

Greenwich, May, 1923.

*Communicated by Sir F. W. Dyson, F.R.S.

COMPARISON OF GREENWICH AND OTTAWA OBSERVATIONS OF ANNAPOLIS AND BORDEAUX WIRELESS TIME SIGNALS

Automatic Registration at Greenwich

Date 1922	Annapolis Signals (Washington noon)			Bordeaux Signals	
	Greenwich minus Washington	Ottawa minus Washington	Greenwich minus Ottawa	Greenwich minus Ottawa	
				1st Sig.	300th Sig.
	s.	s.	s.	s.	s.
July 3				+0.19	+0.18
4				+0.19	+0.19
6				+0.20	+0.19
7				+0.19	+0.19
9				+0.20	+0.21
24				+0.19	+0.21
26				+0.32	+0.32
Aug. 4	+0.08	−0.06	+0.14		
6	+0.02	−0.08	+0.10		
7	−0.04	−0.08	+0.04		
9	+0.04	−0.04	+0.08	+0.11	+0.12
10				+0.12	+0.14
11	+0.11	−0.01	+0.12	+0.14	+0.13
12				+0.14	+0.15
13	+0.11	−0.02	+0.13	+0.17	+0.18
16	+0.16	−0.10	+0.26		
19	+0.01	−0.11	+0.12		
20	+0.01	−0.10	+0.11		
21	+0.03	−0.06	+0.09		
22				+0.15	+0.14
23				+0.14	+0.12
24	+0.01	−0.06	+0.07		
27				+0.20	+0.22
28	+0.08	−0.11	+0.19		
29				+0.23	+0.22
30				+0.11	+0.11
Sept. 1	+0.07	−0.09	+0.16	+0.15	+0.14
6	+0.08	−0.04	+0.12		
12	+0.07	−0.08	+0.15		
14				+0.16	+0.18
15	+0.08	−0.07	+0.15	+0.17	+0.14
20	+0.06	−0.04	+0.10		

Date 1922	Annapolis Signals (Washington noon)			Bordeaux Signals	
	Greenwich minus Washington	Ottawa minus Washington	Greenwich minus Ottawa	Greenwich minus Ottawa	
				1st Sig.	300th Sig.
	s.	s.	s.	s.	s.
Sept. 21	+0.05	−0.05	+0.10	+0.10	+0.11
22	+0.05	−0.05	+0.10	+0.11	+0.12
23	+0.13	−0.04	+0.17		
24	+0.08	−0.02	+0.10	+0.13	+0.13
25				+0.08	+0.10
26	+0.10	−0.01	+0.11	+0.09	+0.11
27	0.00	−0.01	+0.01	+0.08	+0.09
28				+0.09	+0.08
29				+0.12	+0.12
30				+0.18	+0.17
Oct. 1	+0.05	−0.08	+0.13	+0.14	+0.14
2	+0.06	−0.06	+0.12	+0.14	+0.13
3	+0.05	−0.05	+0.10	+0.13	+0.13
4				+0.11	+0.12
5				+0.08	+0.07
6				+0.07	+0.07
7				+0.07	+0.07
9				+0.09	+0.07
10				+0.08	+0.08
11				+0.09	+0.09
12	+0.03	+0.01	+0.02		
13				+0.01	+0.01
14	+0.11	+0.02	+0.09		
16	+0.05	−0.02	+0.07	+0.02	+0.02
17	+0.04	−0.02	+0.06		
18	+0.04	−0.02	+0.06	+0.09	+0.09
19	+0.02	−0.01	+0.03	+0.05	+0.03
20	−0.11	−0.03	−0.08	+0.04	+0.03
21	−0.08	−0.06	−0.02	+0.02	+0.02
22	0.00	−0.05	+0.05	+0.07	+0.08
23	−0.01	−0.06	+0.05		
24	−0.02	−0.11	+0.09	+0.11	+0.11
25	−0.01	−0.09	+0.08	+0.09	+0.08
26				+0.06	+0.07
27	−0.05	−0.05	0.00	0.00	+0.01
28	−0.05	+0.03	−0.08	−0.01	−0.01
29				+0.01	+0.01
30	+0.02	0.00	+0.02	+0.03	+0.02
31	−0.01	0.00	−0.01	+0.03	+0.02

Monthly Mean Results

Abstract I

1922	Greenwich minus Ottawa By Annapolis Signals	By Bordeaux Signals
July		+0.21
Aug.	+0.12	+0.15
Sept.	+0.12	+0.12
Oct.	+0.04	+0.06

Abstract II

1922	Direct comparison of Greenwich and Washington	Bordeaux	Paris Rhyth. 10th	Nauen noon
July		+0.19	+0.11	−0.01
Aug.	+0.05	+0.19	+0.14	+0.08
Sept.	+0.07	+0.18	+0.13	+0.04
Oct.	+0.01	+0.15	+0.12	+0.01

NOTE.—The length of the Annapolis signals is approximately 0.3 sec., while the Bordeaux signals are much shorter, less than 0.1 sec. In a letter from Mr. Bowyer it is stated that for the Bordeaux signals the reference point adopted at Greenwich is the middle of the signal; at Ottawa the beginning is taken. The mean difference between the monthly values of "Greenwich—Ottawa" as obtained from Annapolis and from Bordeaux is 0.02 sec.; increasing this by 0.02 sec. for transmission time we have 0.04 sec., which is very nearly half the length of the Bordeaux signals.

R. M. S.

WIRELESS TIME SIGNALS OBSERVED AT OTTAWA

By R. Meldrum Stewart

Bulletin No. 4

THE quantities given and their arrangement are the same as in previous bulletins.

About the middle of March it was discovered that a mechanical fault had developed in Riefler 412, the clock to which the time signals were being referred, resulting in a semi-diurnal fluctuation in rate which had by that time assumed considerable proportions. On investigation it was found possible to trace back this fluctuation for somewhat over a month, but no further; however, it has been considered safer to give no results which could have been affected by it from the beginning of the year. Since a comparison was made between the two clocks each night at 10 p.m. it has been possible to use the Annapolis results for that hour by referring them to Riefler 75.

During March and April an investigation was made of the systematic error of reception by the method of coincidences by extinction. For a double-wave station, if we assume that the interval between the ending of the back wave and the beginning of the front wave is inappreciable, it is evident that the result should be the same whether we tune to the front wave and observe the beginning of the signal, or to the back wave and observe the end of the signal, the difference, if any, being double the systematic error. Comparisons were made by observing coincidences during a single series of signals alternately by each of the above methods; the mean difference obtained from a series was treated as a single measure. Three observers, designated as H, S and D, were engaged; it had been thought previously that a slight personal equation existed, the observers anticipating one another in the order named. The mean differences for Annapolis signals were all in the sense of a lag (*beginning* of signals observed too late), and were as follows:

	s	s	
H	+.002	±.001	(45 measures)
S	+.006	±.001	(38 measures)
D	+.021	±.003	(4 measures)

The last result is obviously of very low weight; the systematic errors indicated are in each case half the above quantities.

An attempt was made to obtain similar measures for the Lafayette signals, but this appeared impracticable on account of the extreme shortness of the signals.

Dominion Observatory,
Ottawa, July, 1923

1923 Date		10 p.m. Ott.—Wash. Obs.	Cor.	ΔT at 10 p.m. Observed	Adopted	1923 Date		10 p.m. Ott.—Wash. Obs.	Cor.	ΔT at 10 p.m. Observed	Adopted
		s	s	s	s			s	s	s	s
Jan.	1	+.04	−.06		−0.575	Feb.	1	−.04	−.11		+0.315
	2	+.04	−.04	−0.514	−0.520		2	+.05	−.10		+0.347
	3	+.07	−.04		−0.468		3	−.03	−.10		+0.380
	4	+.13	+.04		−0.420		4	−.03	−.06		+0.412
	5	+.20	+.08		−0.373		5	−.03	−.04	+0.445	+0.444
	6	+.24	+.15		−0.326		6	+.02	−.03		+0.475
	7	+.21	+.15		−0.279		7	+.08	+.02	+0.506	+0.506
	8	+.27	+.21		−0.232		8	+.06	+.04		+0.544
	9	+.32	+.23		−0.185		9	+.15	+.09	+0.568	+0.585
	10	+.35	+.24		−0.138		10	+.20	+.10	+0.661	+0.627
	11	+.34	+.23		−0.092		11	+.19	+.09		+0.653
	12	+.30	+.21		−0.045		12	+.16	+.08		+0.665
	13	+.28	+.20		+0.002		13	+.16	+.08		+0.666
	14	+.30	+.18		+0.049		14	+.22*	+.07		+0.684
	15				+0.096		15	+.08	+.06	+0.670	+0.714
	16	+.20	+.09		+0.143		16	+.07	+.04	+0.812	+0.755
	17	+.15	+.09		+0.190		17	+.05	+.08		+0.773
	18	+.14	+.07		+0.238		18	+.03	+.08		+0.775
	19	+.17	+.10	+0.284	+0.288		19	+.07	+.08	+0.750	+0.766
	20	+.21	+.09		+0.341		20	+.13	+.08		+0.770
	21	+.21	+.11		+0.378		21	+.18	+.08		+0.793
	22	+.17	+.06	+0.453	+0.381		22	+.17	+.07	+0.797	+0.827
	23	+.19	+.02	+0.342	+0.333		23	+.16	+.07	+0.914	+0.866
	24	+.13	+.06		+0.259		24	+.11	+.06		+0.882
	25			+0.161	+0.181		25	+.11	+.06		+0.879
	26	+.14	+.08		+0.133		26	+.09	+.03		+0.862
	27	+.11	+.05	+0.069	+0.122		27	+.05	−.01		+0.844
	28	+.15	+.11		+0.152		28	−.01	−.05		+0.827
	29	+.03	−.04	+0.217	+0.199						
	30	−.03	−.06		+0.245						
	31				+0.282						

*Signals sent by Sayville; lag .15 sec.

1923 Date	Ottawa—Washington Observed Noon	Observed 10 p.m.	Corrected Noon.	Corrected 10 p.m.	Lafayette (G. Sid. T.) 1st beat	300th beat	ΔT at 10 p.m. Observed	Adopted
	s	s	s	s	h m s	h m s	s	s
Mar. 1		.00		−.03				+0.809
2		+.15		+.06				+0.792
3								+0.774
4		+.15		+.07				+0.751
5		+.22		+.12			+0.739	+0.719
6								+0.671
7		+.22		+.10				+0.631
8		+.18		+.11			+0.551	+0.608
9		+.25		+.17			+0.641	+0.615
10		+.28		+.19				+0.624
11		+.24		+.14				+0.629
12		+.23		+.12				+0.623
13		+.02		+.04				+0.626
14		−.07		−.01			+0.611	+0.648
15	+.01	+.02	−.02	−.02	7 37 0.81	7 41 53.97		+0.698
16	+.08	+.10	.00	+.02	42 13.85	47 7.01		+0.766
17	+.10	+.10	+.04	+.01	45 29.62	50 22.79	+0.845	+0.844
18	+.14	+.15	+.03	+.05	46 47.69	51 40.85		+0.915
19	+.09	+.12	+.01	+.05	52 0.86	56 54.02	+0.990	+0.966
20	+.11	+.10	+.03	+.03	56 15.08	8 1 8.25		+0.999
21	+.06	+.08	−.01	+.02	8 0 29.24	5 22.40		+1.028
22	+.13	+.16	+.06	+.10	6 41.10	11 34.27		+1.073
23	+.12	+.08	+.08	+.04	8 57.39	13 50.55		+1.101
24	+.07	+.10	+.02	+.01	12 12.60	17 5.76	+1.166	+1.133
25	+.11	+.15	+.01	+.04	15 28.25	20 21.42		+1.138
26	+.13	+.10	+.01	.00	18 44.03	23 37.19	+1.109	+1.144
27	+.09	+.09	−.04	−.02	23 57.46	28 50.62		+1.176
28	+.06	+.06	−.06	−.03	27 13.13	32 6.30		+1.242
29	+.05	+.04	−.04	−.03	31 27.23	36 20.40		+1.304
30	+.04	+.06	−.02	.00	35 41.52	40 34.68		+1.381
31	+.01	+.07	−.02	+.02			+1.460	+1.445

1923 Date		Ottawa—Washington Observed Noon	Observed 10 p.m.	Corrected Noon	Corrected 10 p.m.	Lafayette (G. Sid. T.) 1st beat	300th beat	ΔT at 10 p.m. Observed	Adopted
		s	s	s	s	h m s	h m s	s	s
Apr.	1		+.07		+.03	8 40 14.97	8 45 8.13		+1.501
	2	+.07	+.07	+.02	+.02	48 24.48	53 17.64		+1.549
	3	+.08	+.10	+.01	+.03	53 37.49	58 30.65		+1.611
	4		+.06		+.02	56 53.05	9 1 46.22		+1.686
	5	−.01	+.05	−.01	+.03	58 10.55	3 3.71		+1.728
	6	+.07	+.05	.00	+.01	9 3 23.28	8 16.44	+1.788	+1.778
	7	+.04	+.03	−.02	.00	13 30.81	18 23.98		+1.818
	8	+.05	.00	−.01	−.04	10 54.18	15 47.35		+1.837
	9	+.08	+.05	−.02	−.01	15 9.40	20 2.56	+1.862	+1.860
	10	+.08	+.07	−.03	−.01	20 23.65	25 16.81		+1.881
	11	+.05	+.05	−.04	−.02	25 36.99	30 30.15		+1.901
	12	+.06	+.09	−.04	−.01	26 55.11	31 48.27		+1.921
	13	+.05	+.05	−.02	−.03	31 10.21	36 3.37	+1.939	+1.943
	14	+.05	+.05	−.02	−.01	36 23.98	41 17.15	+1.967	+1.968
	15		.00		−.05	38 41.59*	43 34.75*		+1.996
	16	+.07	.00	.00	−.04	44 53.44	49 46.60		+2.023
	17	+.10	+.10	+.04	+.04	49 7.11	54 0.27	+2.053	+2.046
	18	+.08	+.07	+.02	+.02	51 23.53	56 16.69		+2.050
	19	+.08	+.07	−.01	−.01	56 35.59	10 1 28.74	+2.079	+2.044
	20	+.13	+.16	+.03	+.05	59 50.10	4 43.26	+1.961	+2.029
	21	+.15	+.10	+.03	+.01	10 5 2.38	9 55.54	+2.049	+2.035
	22	+.05	+.06	−.02	−.01	8 17.48	13 10.64		+2.032
	23	+.03	+.05	−.04	−.03	18 24.47	23 17.63	+2.057	+2.019
	24	+.11	+.13	+.02	+.07	15 46.72	20 39.89	+1.955	+1.988
	25	+.23	+.14	+.04	+.06	19 2.83	23 55.99	+1.933	+1.958
	26	+.11	+.13	+.03	+.04	26 14.28	31 7.44	+1.979	+1.937
	27	+.09		+.02		31 27.52	36 20.68		+1.928
	28	+.01	+.07	−.02	.00	32 45.00	37 38.17		+1.888
	29	+.02	+.08	−.02	+.05	33 3.62	37 56.78		+1.794
	30	+.11	+.17	+.02	+.08	36 18.51	41 11.67		+1.701

*Second series 9h 44m 34.57s, 9h 49m 27.73s

STAR MYTHS

By C. R. COUTLEE

THE myths of the ancient star groups constitute the oldest short stories and their fanciful figures are the oldest movie pictures. Probably the Akkadians, or ancient Highlanders of Asia first arranged the star pictures, then followed the Assyrians. Babylonian tablets, the oldest records, reveal that before 3000 B.C. the Akkadians had introduced a sphere and zodiac. The designers, however, of the groups as known, lived between latitude 36° and 42° north, that is in Asia Minor, not in the cities of Egypt or Babylon. The elephant, camel, hippo, crocodile, tiger and cat are absent, so India and Egypt had no hand in the panorama. Fish, sea monsters, also a ship, appear and about a quarter of the sky pictures is used for fantastic marine shapes, so the inventors were a coast or island people along the shores of ancient Greece at the east end of the Mediterranean. We see no walls of Troy, however, nor serried ranks of fighting men. The sky story is all before Homer's time, before Troy 1180 B.C. There are, however, serpents and monsters in plenty seeming to refer perhaps to conflicts of prehistoric men with huge floundering brontosaurs, perhaps still inhabiting the swamps of southern Europe.

Crete had a civilization 25 centuries B.C., then came the Greeks 20 centuries B.C. and Homer flourished 10 centuries B.C. The Greeks thought that the earth was flat and circular, Mount Olympus in Thessaly being the centre. The Mediterranean and its extension, the Black sea or Euxine, divided the world into two and these were the only oceans that the ancients bothered about. Around the flat circular earth flowed the river Ocean northward up the west side and southwards along the east in a steady current with no storms nor tempests. The Hyperboreans dwelt in eternal spring and bliss exempt from disease and old age to the north, and to the south of the sea were the Ethiopians, happy and virtuous and so favoured that the gods condescended at times to dwell with them and even to share their sacrifices and banquets. Geo-

logically the Mediterranean was once two seas, but when the fourth glacial cover melted, the surface of the Atlantic was raised considerably and it flowed into the Mediterranean and the Black Sea. The sun rose out of the river Ocean on the east side and drove through the air to enter the ocean on the west with a hiss, where it embarked in a winged golden boat to pass around the north to its rising point again. The moon made the same trip by night and so did all the stars except the circumpolar ones which never touched the water.

The Greek gods and goddesses were all active, motor-type characters and full of the faults of such characters. Their origin was as follows: Earth, Sea and Air were all at first mixed in a jumble called Chaos. Then the Earth sank and was buoyed up by the Water and the Air made the skies. Stars appeared, and in the waters fish, while birds and animals inhabited the new made land. The geological record indicates a steaming swamp filled with saurins, pterodactyls and icthiosaurs. Then came man into this landscape of thrashing-tailed, gigantic, fearsome creatures.

King Saturn reigned in Crete and all things were golden but the one fault of this monarch was a tendency to eat up his family, Jupiter, Neptune and Pluto. These husky boys naturally rebelled, the Titans were conquered and imprisoned in Tartarius except Atlas, who was condemned to hold upon his shoulders both the earth and sky. Jupiter, or Zeus, now ruled all with the power of his thunder to enforce his decrees. He delegated the Sea to his brother Neptune (Poseidon) and the realms of the dead to Pluto (Dis), while Mars was the God of War. Phoebus Apollo, born in Delos, was god of the mental light of the Sun and of sports. Diana, his twin sister, was goddess of the mental light of the moon. Sol was physical sunlight and Luna (Selene) was physical moonlight. Venus (Aphrodite) sprang from the foam of the sea at the island of Cyprus, she was the goddess of love and beauty. Mercury was the messenger god of commerce, wrestling and games of skill and dexterity and even thieving. Ceres, a sister of Jupiter, gave wheat, agriculture and the harvests. These gods lived in mansions along the milky way, Jupiter's residence was headquarters for meetings to discuss affairs of state and for banquets of ambrosia and nectar which were handed round by Hebe.

The sun was the source of all creation to the ancients. The Caldeans seem to have organized the sun worship, firstly as father of gods and men, then as the source of the king power. The Phoenicians held festivals in February and March to Hercules whom they considered the sun god of giant strength. Greece changed from the worship of nature to the worship of a spirit created by the mind. Apollo was the greatest and highest type of sun god that man invented. He was the spiritual light of the sun shedding benign radiance, but also extremely powerful, governing life and death, but doomed to work under strict discipline. Helios was the physical light of the sun and it was his duty to drive the horses and chariot.

The Greeks held the idea that the whole solar system was a ship with the planets as sailors and the sun as captain and pilot. The American Indian was very rich in sun legends. They considered that the world remained in darkness till the sun was captured and made to follow his daily path. The sunset colours were due to the gorgeous blanket in which he wrapped himself at night. The Ottawa Indians considered the sun and moon as brother and sister and they had a sun hero who placed dams in the great lakes, and did other wonderful deeds. They smoked the sun, the pipe being handed from chief to chief, and they were fire worshippers, setting fire to the oil that oozed from the ground in Pennsylvania, just as the Persians did at Baku. Rude temples have been found in the American southwest but in Mexico and Peru magnificent temples were erected profusely ornamented with gold, and human sacrifices were offered to the sun frequently. This was likely the custom in Britain at Stonehenge where the shadows of certain vertical stones fell upon the altar in the middle at the summer solstice.

There are many sun catching myths, the idea was to subdue and train the sun. Hooks have been found in a pass of the Andes from which a net was hung to make a trap for the sun. The Australian natives placed stones and other articles in the trees supposing that the sun would be retarded and remain up until they returned from hunting in the evening. Festivals were held by all nations upon the longest and shortest days. In Northern Europe these were called Yole from which we get our words, wheel and Yuletide. A wheel of straw was set on fire and rolled down

hill between lines of shouting people. The need fire, invoked to stop plagues among men and animals, was lit by revolving a wheel rapidly upon a wooden axle that took fire. In Egypt a black bull, representing darkness, with the moon painted on one side and the sun on the other, was sacrificed by drowning in the Nile upon the longest day. The orientation of temples was common to all nations.

The moon inspires people to see many images upon its face. In Northern Europe they tell of a man breaking the Sabbath day by carrying wood upon his back, not golf sticks, and being sentenced to stay there forever. Selene, sister of Helios, in Greek mythology, loved the shepherd, Endymion, a beautiful youth, who sank into eternal sleep when she kissed him. It has been worshipped by all nations and the custom of looking over the shoulder, bowing, etc., recalls Druid rights in England. In Peru it was considered the mother of the Incas.

There were five naked eye planets known to the ancients. Mercury was discovered eighty years after the death of Alexander the Great, or 321 B.C. Venus was the zenith of poetic suggestion which Homer called "the beautiful". At first it was thought to be two stars, Phosphorus in the morning and Hesperus in the evening. Mars or some red star seems to have inspired Lilly's prediction of the London fire 1666. Jupiter, an immense globe of vapour, derives its name from its great size. Saturn to the Greeks was the most distant and so called Cronos, Latin Saturn. Like Jupiter it is a globe of vapour. Uranus was discovered in 1781 by Herschel, a musician who made telescopes and became astronomer royal.

The usual myth associated with each constellation follows taking those along the zodiac first and then those situated above the Ram, the Bull, etc:

Aries the ram in Greek mythology recalls the story of Phrixus and Helle, children of the King of Thessaly, who were badly treated by their step-mother, and Mercury in pity sent a ram with golden wool so they could escape. Helle fell off into the Hellespont, but Phrixus got safely to Colchis at the east end of the Black Sea. He sacrificed the ram to Jove and gave the fleece to King Aetes, who hung it in a sacred grove guarded by a sleepless dragon. The

recovery of this originated the voyage of the *Argo*, which Sir Isaac Newton thought was the origin of the star groups.

Taurus the bull, tells the world that when Jupiter kidnapped Europa, he assumed the shape of a white bull with golden horns and hoofs. She sat on the animal which took wing to Crete, speeding over the waves, while troops of Nereids on backs of sea monsters lined the way. The Hyades in the face of the bull are the daughters of Atlas, half sisters of the Pleiades and were changed to stars owing to their grief over the loss of their brother Hyas. The Pleiades are in the shoulder of the bull and many nations held memorial services for their dead when these were prominent. The culmination of this cluster was regarded with superstitious awe by the Astecs, the Japanese, the Peruvians and the Mexicans. Our Indian legend is that a fabulous buffalo stole the sister of seven brothers and kept her prisoner, but the youngest brother tunnelled beneath the herd and got her back. The buffaloes attacked, but sister and brothers were taken up to the sky. The Greeks considered that they were the seven daughters of Atlas, who with the seven half sisters were placed in the sky to represent amiable virtues and mutual affection. One Pleiad, Electra, hid her face to avoid seeing the fall of Troy and is not seen now.

Gemini, the twins, were the sons of Jove and joined the Argonauts, displaying great courage. During a storm on the *Argo*, flames played around their heads and the sea became calm, as Neptune had given them power over wind and waves. Returning from Colchis they waged war against pirates in the Hellespont and so became the friends and protectors of sailors and navigation. The Romans thought that Castor and Pollux fought for them at Regillus and placed the twins upon their coins. Our slang, "By Giminy", is a Roman oath. The Romans used them as figure heads on their vessels and when Paul sailed from Malta to Syracuse, the sign of the vessel was two stars.

Cancer, the crab, is also represented as a tortoise, a beetle and a scarab in Egypt. According to the Greeks it is the crab that bit the foot of Orion when he boasted of subduing all animals. He crushed it under his heel but Juno placed it in the sky as a reward. Also said to represent the asses that carried Bacchus and Silvenus and brayed frightening the giants. In Yucatan there

was a temple dedicated to Cancer and when the sun was in the sign, it was supposed to consume the sacrifice upon the altar. The Praesepe or Manger is a cluster from which the asses feed. In English folk lore it was called the bee-hive. It is an aggregation of 363 suns and at times it has been mistaken for a comet. The planet Jupiter was noted as in the Manger 240 B.C., 83 years after Alexander the Great. In 1895 all the planets except Neptune were in or near Praesepe. If not visible on a clear night violent storms may be expected.

Leo, the lion, was considered by the Greeks to represent the Nemean lion that was slain by Hercules who afterwards wore a lion's skin for a cloak.

Virgo, the virgin, represents the ancient goddess Ceres, daughter of Vesta, the virtuous matron who taught agriculture and presided over harvests. The Greek poets considered Virgo the goddess of Justice, having scales to weigh the good and evil deeds of men. She resided on earth during the Golden Age, but the wickedness was so great after that, that she was obliged to leave. Her daughter Proserpine was kidnapped by Pluto. Ceres then besought Jupiter, after she located her, to have her brought back, but he ruled that because she had eaten in the underworld she must remain there part of the time at least, coming to earth for seed time and harvest.

Libra, the scales, appears as the only inanimate object and probably represents the equal division of day and night at the equinox. The Greeks included it with Scorpio, but the Romans originated the constellation imagining that Julius Caesar held the balance.

Scorpio, the scorpion, was supposed to have sprung from the earth at the command of Juno to sting Hercules when he was overcoming the Learnean Hydra.

(*To be concluded*)

THE NORSE DISCOVERY OF AMERICA
(IN A.D. 1000)

By ALBERT DURRANT WATSON

WHEN we contemplate the various tribes of ancient America,—The Mexican subjects of Montezuma, the Peruvians encountered by Pizarro, the Aztecs, the Mound Builders, the Skralings of Lief Ericsson, the Eskimos, and the Red men; the whole continent seems to rise as one question: "How many times has America been discovered?" Monuments, traditions, maps, manuscripts, poetry, chronicles, inscriptions—all kinds of evidence abound of the early presence of Man upon this continent. Some of these monuments have been found as far south as Florida and as far west as Ohio, to say nothing of the mound builders, the Aztecs, etc. One conviction only can result from their consideration: to doubt the fact of the discovery of America in pre-Columbian times is to show oneself hopelessly uncritical or else altogether uninformed.

And yet, the story of the discovery of America by the Norsemen nearly a thousand years ago was long regarded as a fabulous or legendary exploit involving more romance than truth. The more recent appearance from unsuspected sources of accounts independent of each other, of expeditions to a land which could have been none other than America, has shown at least a nucleus of authentic history and confirmed the earlier traditions of these interesting expeditions. One central fact stands undisturbed by criticism. It is the assurance that Leif Ericsson of Iceland landed on this continent during or about the year A.D. one thousand.

The sentiment of some facts is like the fragrance of a pine forest, or the incense of new mown hay, or the perfume of full blossom in an apple orchard. It is the dream-atmosphere of this fact that holds us. The subject bristles with new questions. In what latitude did the Norsemen land, and where did they for the time make their home? This question seems to demand more attention from Canadians than it has hitherto received.

Let us now turn eastward to the land of the Vikings and the Volsungs; lands where the jokuls rise with glittering pinnacles to

the sun, while floods tear away the detritus worn from the coasts by slowly descending glaciers, indenting them with floi and fjord and creek, all of them of great depth. Into these waterways the sea rushes among the promontories, breaking through many a narrow wall and leaving scarp and ness transformed into islands that, like the sharp, black teeth of some submarine giant, jut out of the restless sea. Most of the islands are of this character, but sometimes the peak is worn off, and the little insular area is left flat and accessible. Such an island is so unusual that it is known generally as the Flat Island. Of these there are several. The one to which our interest is directed in this study lies in that great bay known as the Breidafjord, which, together with the Hunafloi on the opposite shore of the isthmus, makes the north west portion of Iceland a peninsula. This isthmus is only four and a half miles in width.

On this Flat Island, or Flatey Island, lived Jonas Torfason, in the middle of the sixteenth century. To him had descended from his fathers a treasure in the form of a parchment containing songs and sagas concerning the settlement of Norway, the sagas of the Orkneys, of Greenland and the Helge. It tells of voyages to Greenland and to Vinland, gives many memoirs of important persons, and contains the reputed annals of the world from the creation down to the period of writing which is named in the documents as the year A.D. 1387. With such a wide scope, can we wonder that only a few incidents concerning the discovery of a far-off and almost forgotten land found their way into the volume, even though it contained as many as seventeen hundred pages?

Brynjulf Sveinsson, Bishop of Iceland, was commissioned by King Frederick III of Denmark, in the middle of the seventeenth century, to collect manuscripts and other monumental works of interest to the kingdom. Many valuable documents were secured, but the most beautiful and important of them all was the one belonging to the Torfanson family. It had been carefully protected and preserved for generations.

The owner of the parchment was obdurate for a time in his refusal to part with his treasure. When the Bishop visited him and presented the matter in a new light, Jonas was persuaded to present the manuscript to the Bishop, whereupon his generosity

was rewarded by the exemption of his lands from ecclesiastical taxes. This parchment is now known as the Flateyjarbok or the Flat Island Book. Its present home is the Royal Library in Copenhagen. On its first page, John Hakonson is declared to have been its first owner.

Another volume of importance, The Hauk Book, was written by Hauk Erlendsson and his scribes during the period between the years 1299 and 1334. Erlendsson was a highly critical scholar and historian, interested in the sagas of his people. His handwriting, preserved in other archives, confirms the fact that he wrote part of the work himself. It contains the Landnamabok, a sort of doomsday book for Norway of which nation Iceland was then a colony. It covers many Icelandic matters, among others, the account of the voyage of Thorfinn Karlsefne to Vinland, the name by which Leif Ericsson had designated the far-off western lands. This work is preserved in the library of the University of Copenhagen.

Before Knut the Dane had conquered the English north-country, and long ere Harold Hardrada had met his fellow-Norseman, William the Norman, at Stamford Bridge, there was much naval activity among all the Norse peoples. They were by nature adventurers and explorers. Beginning in Norway, they adventured first to Iceland and later trafficked with the Culdees of Ireland, then passed to Greenland and last to Vinland or, as the Irish named the new lands, to Greater Ireland.

No wonder then that when the vikings were thwarted for a time by the Great Alfred of Wessex, and sat around the mead-bowl, they shaped their dreams to new conquests in more remote quarters of the sea. It is not unlikely, indeed, that the grandfather of Eric Ericsson, or even his father, had helped to man the ships of Guthrun when he sailed against Alfred. At least we know that the Norse influence had reached Ireland, Iceland, Greenland, England and Gaul before the days of Leif Ericsson.

Let us turn now to Eric Ericsson, known as Eric the Red. He was the son of Thorvald and was a man of aggressive temper. This was quite in contrast with his son Leif who is said to have been "a very moderate man in all regards."—(Flatey Book.) Both men were tall, vigorous and valiant. Eric was a great massive,

red, long-limbed sea-rover used to the mastery of the horse as thoroughly as to the mastery of his ship. He wore a coat of mail with the head-gear common to the sea-kings, surmounted with a walrus and, on the side, with raven wings. We can picture him as a viking chief mailed and casqued, a figure of strength and personality.

Eric's fiery temper led him more than once to make fatal onslaught upon his foes. This was no great hindrance to his viking fame though it compelled him to seek a new home, and thus led to more than one historic migration. We may best tell the story in the quaint words of the Flatey Book:

> Eric the Red, his (Thorvald's) son, went from Joederen to Iceland for manslaughter's sake. Then was widely colonized Iceland. They lived first on Drange . . . There died Thorvald . . . Eric married then Thorhild . . . Went Eric then north and took abode at Ericsstad beside Vatnshorn. Eric's and Thorhild's child was called Leif. But after Eyulf Sor's and Duelling Rafn's slaughter, Eric was made away from Hokedal. Went he westward to Breidafirth and took abode in Oxney at Ericsstad. He lent to Thorgest his seat-posts, and got them not back; he then claimed them. Thence was made quarreling and fighting with them.

The whole settlement seems to have taken sides. The lists are given in the record. Thorgest won out, though why this was, it is hard to say. The story of the result is stated tersely:

> Eric was outlawed at Thorness Thing. Made Eric then his ship ready to sail . . . Eric said to them that he intended to search for that land which Gunbiorn, Ulf Krage's son saw, when he was driven westward across the ocean . . . said he back might go for his friends if he found the land. Eric sailed away from Snowfell's Jokul.

The record tells how he found the land (Greenland) and gave local names to places there and returned in the third summer to Iceland. It seems to have been at this time that he found a plausible name for the land he had discovered. The record proceeds:

> He came in his ship to Breidafirth. He called the land that he had found Greenland; for he said: that might attract men thither when the land had a fine name. Eric was on Iceland during the winter, but on the summer after, he went out to settle the land . . . Then three tens and a half ships sailed out of Breidafirth and Borgarfirth, and fourteen came out thither. Some were driven back and some cast away. That was XV winters before Christianity was fixed by law in Iceland.

There can be little doubt that Leif Ericsson was with his father on most of these expeditions, and was familiar with all his goings. He knew how Eric had discovered Greenland in A.D. 985, how he had spent two winters in the land of the glacier mountains, one on the eastern and one on the western shore, and how he had returned to Iceland in the spring of 988 and there prepared to settle the new land. After the Ericssons had been fifteen summers in Greenland, Leif took ship for Norway and visited Olaf the King. The Ericssons were now people of consequence. The record proceeds:

> Leif laid his ship in at Nidaros and went at once on a visit to Olaf King. Expounded the king the faith to him as to other heathen men who to visit him came. Was to the king this easy with Leif; was he then christened and all his shipmates too. Was Leif with the king all the winter well treated.

Another distinguished family now enters the story. This was the Heriulfs. Heriulf was the son of a bard. Thorgerd was his wife. Their son was Biarne, a most promising young man who had the spirit of a sea rover from his youth. The Heriulfs were wealthy and much esteemed, and Biarne was every winter either abroad or with his father in Norway. He soon owned a ship and set about a Greenland voyage with Eric and his father. They settled at Heriulfsness and were highly regarded. Eric the Red dwelt at Brattalid:

> He was there with most esteem, and louted all to him. These were Eric's children: Leif, Thorvald and Thorstein, but Freydis was called his daughter . . . She was wedded to a man named Thorvard . . . She was very proud, but Thorvard was a little man. She was chiefly given to him for his wealth's sake. Heathen were the people in Greenland at that time.

It is unnecessary to follow Biarne Heriulfson further than to relate that in his search for his father, who had gone to Greenland, he was driven by unfavourable winds far to the south-west, and that after drifting many days without compass or astrolabe on unknown seas, he sighted land, which we now know to have been a portion of the mainland of this continent. Hauk Erlendsson says in the Landnamabok (writing about 1300):

> Floki, son of Vilgerd, instituted a great sacrifice and consecrated three ravens which should show him the way; (to Iceland) for at that time no men sailing the high seas had lodestones up in northern lands.

The compass came into use in Norway about the middle of the thirteenth century. Biarne, intent upon finding his father, did not land, as the coast had no resemblance to the description he had received of his father's home in Greenland. The land he saw was "mountainous and wood-grown" and had small hills. After sailing with land on the larboard for two days, they sighted land once more. This coast was flat and well-wooded. He knew that this was not Greenland, for said he: "Glaciers are very large said to be in Greenland." His men wanted to land, but Biarne would not. He then sailed for three days before a south-western wind, and on the third day found high and mountainous land with glaciers upon it. Still Biarne refused to land, but finding it to be an island, he sailed on before a strong wind for four days and, strangely enough, came to the place where his father dwelt. He then stayed with his father till the death of the latter.

The story of Biarne Heriulfson was told far and wide, and when he came to visit Eric Ericsson, it was thought very strange that he had landed on none of the points where he had seen the land. Leif Ericsson bought Biarne's ship, hired a crew and set sail with thirty-five men to find the land which Biarne had been the first to see. Leif urged his father to command the expedition. Eric consented after much persuasion, but on his way to the ship,

> The horse stumbled which Eric rode, and fell he off from its back and hurt his foot, then quoth Eric: Not is for me fated to find more lands than this where we now dwell; we no longer may follow together. Went Eric home to Brattalid, and Leif went to the ship, and his fellows with him, three tens and a half men. There was a southern man with them who Tyrker was called.

Leif found the land which Biarne had last seen, but as it seemed good for nothing, he followed Biarne's example and declined to land. He called the place Helluland or stone-land. This was probably a part of the coast of Labrador.

Leif then sailed to the south and came after some days to a thickly wooded coast which he called Markland or forest land. It was level with wide shore and white sand. They landed here, but soon took ship once more, and sailed on for two days ere they saw land again. This, according to the account in the Flatey-jarbok, was the place which they called "Vinland" because they

found grapes there. In order that the reader may have a precise statement, we quote the text there:

> They were so eager to go ashore, that they could not bide that the high water should rise under their ship, but ran to the land, where a river fell into the sea from a lake. They took the boat and rowed to their ship and conveyed it up the river; afterwards into the lake, and cast there anchor, and brought from the ship their leather bags, and made there booths. Took resolution afterwards to abide there for that winter and made there a large house. Neither wanted there salmon in the river nor in the lake, and larger salmon than they had before seen.
>
> There was so good land qualities that it seemed to them there might no cattle fodder be wanted in the winter time. There came no frost in winter, and little withered grass. More was there equal length of day and night than in Greenland or Iceland. The sun had there Eyktarstad (sunset after three p.m.) and Dagmala Stad (sunrise before nine a.m.) on the shortest day.

Tyrker, the southerner, discovered "wine-berries" on the land, and after they had cut a ship load of timber and filled their aft-boat with the wine-berries, they returned to Greenland. Eric the Red died shortly after his son's return. Several further expeditions to Vinland followed. During one of these visits to the new world, Snorre Karlsefne was born and spent his first three years in Vinland. He was the first European child born in America as far as we know. All who took part in this expedition were at length compelled to leave the country because of the hostility of the Skralings or native tribes. These at first traded with the Icelanders, bartering the most valuable furs for thin strips of bright-coloured cloth. When the cloth became scarce the strips were cut narrower and the natives did not complain, but accepted them with demonstrations of joy. Their threatening attitude soon became so dangerous that the Icelanders were compelled to leave. When commerce is devoid of love and service, the inevitable penalty follows, and such was the case here.

In discussing the location of Vinland we should remember that these navigators had no clock and no compass. Their statements are evidently surmises in some cases. "There came no frost in winter" cannot be more than a premature surmise. "They could not bide that the high water should rise under their ship" seems to be a reference to the tides, but not necessarily to the high tides of certain bays in the Maritime coasts. The wine-berries could

hardly have been grapes as they have so frequently been regarded. How could they have taken a load of grapes home in the spring or early summer?

On the shortest day, the sun rose before nine and set after three. Mr. J. A. Pearce, now of the Lick Observatory staff, has calculated at my request the lowest latitude consonant with this statement, correcting results for refraction and other modifying influences and conditions. As a result of his calculations he states that "The latitude must have been at least 58° North, and therefore Vinland could not have been farther south than Labrador."

This conclusion is, of course, incontrovertible if we insist upon the data which constitute the basis of our calculation. Professor Fiske* has concluded from the language in the Hauksbook which, on the whole, is even more reliable than the Flatey Book, that the length of the shortest winter's day in Vinland was about nine hours. This, of course, is very different from saying that the sun was above the horizon for that length of time. If possible the indefinite day of Professor Fiske is even more baffling than that of the Flatey Book, though the latter was estimated without a clock. The Professor draws our attention to the fact that a difference of fourteen minutes in the length of the day as measured by the time the sun is above the horizon would make all the difference between the latitude of Boston and that of Halifax. This is true, but the length of the day in question is shorter than is warranted by the supposition that either one or other of these latitudes is to be considered in the question. Then why discuss either?

The answer to this question was found, as was supposed, in the "wine-berries" with which the Greenlanders loaded their ship. Professor Fernald claims that these were mountain cranberries which are edible after lying under the snow all winter. They are found in abundance on the Labrador coast. These and other considerations touching the flora of Vinland have led Professor Fernald to contend that the location of the discovered land was north of the St. Lawrence. It may be contended that the climatic conditions described in the Flatey Book as quoted above warrant us in the conclusion that the land was much farther south. But the statement is made so early in the record that it seems to be

*The Discovery of America.

only a conjecture or a prophecy based upon a warm temperature encountered when the vikings first arrived. It should be remembered too that they had been accustomed to severe weather and would exaggerate any temperate conditions which they might experience.

Professor Storm believes that Helluland or stoneland was Labrador, that Markland or forest land was Newfoundland, and that Vinland was some part of eastern Nova Scotia. In this conclusion there seems to be good reason to concur. In as far as it is an erroneous one, we may be sure the error is in claiming a location too far south. Let us suppose the discoverers sailed 640 miles and arrived at southern Labrador. Helluland could hardly have been farther south, and may have been farther north. But let us suppose it was southern Labrador. They landed, but set sail again putting out to sea. They came upon other land to the south which could not well be any place farther south than Placentia in Newfoundland. This landing was also brief. The place was called Markland. They put to sea again and a breeze from the north-east carried them for *two days* towards the south-west, when they came to another place which they named Vinland. This could hardly have been a land more southerly than Cape Breton, and the direction of their sailing would likely bring them thither. In two days it could scarcely take them farther.

It cannot be claimed in view of the premises that they did actually reach as far south as Cape Breton, but it would appear that they could not have reached farther than that island. Their three points may indeed have been all in Labrador, as Professor Fernald's consideration of the subject would lead one to conjecture. No doubt there were expeditions not recorded in our known histories. It may be that some of the experience of later voyagers may have been blended with those of Leif Ericsson and found their way into the account of his adventures. Such a symposium of experience has entered into the composition of more sacred scriptures than the Flatey Book, and has been ascribed to one author.

The most northerly location attributable to Vinland is probably Hamilton Inlet, Labrador. The most southerly seems, to the present writer, to be some part of the south-eastern shore of Nova

Scotia. In any case, it was probably a Canadian scene. One other view is to be noted. It may be that the term has been applied to all the places visited by Norse navigators that seemed to them to be their ultimate south. In such a case almost any place on the east coast of North America would be in the running. Probably Professor Storm is right in concluding that Helluland was Labrador; Markland, Newfoundland; and Vinland, Nova Scotia.

An article in an American journal was sent me recently containing the statement that the body of a Viking chief had been discovered in the ice far up one of the fjords on the west coast of Greenland. The body was well preserved and clothed in the characteristic garb and accoutrements of a Viking warrior of the olden times. Pictures were included showing the massive form, the coat of mail, the casque with walrus and side wings, the long beard and moustache, the seal-skin wrap, and all the accessories of a sea-king. Allowing for the high-colouring of the modern press, the matter was still interesting.

After carefully looking into the data of the subject, the impression becomes a conviction that Biarne Heriulfson saw the coast of Labrador in A.D. 986, shortly after Eric Ericsson had discovered Greenland; that Leif Ericsson discovered and landed in three places on the east coast in A.D. 1000; that one of these landing places was certainly Labrador, and the other two probably Newfoundland and Cape Breton; that other expeditions visited America and reached presumably as far south as New England or even to Virginia; and that the first European child born on this shore, of whom we have the record, was Snorre Karlsefne.

The claim that Columbus ever heard or knew aught of all this, as certain writers would have us believe, there is no reason to accept. The exploit of Columbus was far more significant than that of Leif Ericsson and should have secured for its hero an everlasting memorial. His name should even yet be given to the continent he discovered. The people of the United States are even now in almost exclusive possession of the title American, while the people of other parts of the continent are called by the names of their countries. If the whole continent were called Columbia all this would be in order. We all should then be Columbians, and all would have their own particular distinguishing title.

However significant the achievement of Columbus, we should never lose sight of the fact that Leif Ericsson, four hundred and ninety-two years before Columbus, sought and found this continent, and though he did not know what he had found—as, indeed, neither did Columbus—the exploit was notable in those days of the unwritten saga, before the compass and the astrolabe. There seems to be reason for commemorating the event also in some monument which will tell to succeeding generations the story of that "very tall man and vigorous, a man most valiant to see, a wise man and a very moderate man in all regards," whom we still know by the title given him by his crew, "Leif the Happy."

REVIEW OF PUBLICATIONS

Cours de Mécanique céleste, par H. Andoyer, Membre de l'Institut. 440 pages, 6½ x 10 in. Vol. I. Paris: Gauthier-Villars, 1923.

In this volume there will be found a systematic treatment of the methods of the classical celestial mechanics with numerous additions original with the author, but a distinguishing feature is the care taken to explain only those theories and methods which can be illustrated by numerical examples. Mr. Andoyer never loses sight of the true object of celestial mechanics and throughout the work he indicates the best formulas for computation and supplies as well the indispensable auxiliary tables.

The present volume contains a summary of the general theories, then a complete study of Keplerian motion, including the problem of the determination of orbits and the numerical calculation of perturbations. The work will be completed in a second volume.

Le Ciel, nouvelle Astronomie pittoresque, par Alphonse Berget, illustré sous la direction de Lucien Rudaux. 312 pp., 9½×12½ in., with over 1,000 illustrations, some in colours. Paris: Librairie Larousse, 1923. Price, bound, 70 francs.

This is a great work. It is a long time since a book on popular astronomy comparable to it was published, if ever there was one. The text is accurate and interesting and the pictures are splendid. On almost every page there are several attractive ones. Of course the achievements of the French people are not minimized, but other nations are well represented too. The price is exceptionally low, about $5, for such a book. It should be in every library and school. The children will simply be delighted to study the pictures, though their elders will be quite as much interested, even if they cannot read French.

C. A. CHANT.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

The Eclipse of the Sun on September 10

On September 10 next there will be an eclipse of the sun, the latter half of the path of totality passing from the southern portion of California south-easterly across Mexico and reaching the Gulf at Tampico. Many expeditions will go from the United States to observe it, the larger number of which have chosen observing stations in the southern end of California near San Diego or in the northern part of Lower California.

The present writer had expected to take a modest equipment to Yrbaniz in the neighbourhood of Cuencame in the state of Durango, where an important expedition from Swarthmore College will be located. The University of Toronto made financial provision for the expedition and preparations were under way, but matters have arisen which will prevent the arrangements from being completed and the writer hardly expects to see the eclipse. The proposed programme included observations for polarization and for the "flash" spectrum.

A Great Flood in New Zealand

During the last three or four years the Journal has published a number of interesting observations made by Mr. B. S. Wimbush, of Garden Plain, Alberta. He has now removed to Auckland, N.Z., and in a letter to Mr. W. E. W. Jackson he refers to some great rains in the northerly part of the South Island, and indeed on the east coast of the North Island as well. The record rainfall seems to have been at Keinton Combe where 30.81 inches fell in the 96-hour interval from Friday morning May 4 to Tuesday morning May 8, but very great precipitation took place at other places. At Kaiapoi, where the famous woollen mills make rugs which are world-famed, the workmen were driven from their houses. In some cases the water reached almost to the eaves. Immense damage was done.

It may be remarked that in the neighbourhood of Toronto the annual rainfall is about 30 inches; but it is on record that at Crohamhurst in Queensland, Australia, within 24 hours on February 2, 1893, 35.71 inches of rain fell!

Referring to the southern skies, Mr. Wimbush says: "The stars are very brilliant down here. Jupiter is a lovely sight just now. But I cannot seem to get my bearings yet, with the sun rising on the right hand and going to the left, and the moon's face upside down! In fact the face is not so discernible unless one looks with his head on one side! I have to do quite a bit of figuring to find what direction I am looking in!"

The Moon and the Weather

While sitting at the table beside a gentleman who was conducting a summer school class for the study of sub-normal children, the old subject of the relation of the moon to the weather was referred to. He remarked that it was extraordinary that the belief that the moon influences the weather could be so widespread and yet have no basis in fact.

The next day was July 12. Now in the city of Toronto the Orange order is very strong and on every anniversary of the Battle of the Boyne (though I believe the true date is not July 12 after all), thousands of the citizens, dressed in picturesque costumes, march in procession on the streets to some park where an oration is delivered in honour of King William of glorious, pious and immortal memory. This year the weather was fine; but there is a common tradition which connects the 12th of July with a downpour of rain. Why? In some years there has been a synchronism between an Orange procession and a heavy rain, and that has impressed itself upon the minds of the people. The many days when there was nothing to disturb the celebration are forgotten, and a simple examination of the meteorological records will convince anyone that there is no reason for expecting July 12 to be a rainy day.

So in the case of the moon. At some particular phase there has been some change in the weather at some place, and at once the unthinking jump to the conclusion that one was caused by the other, whereas in most cases there is no change at all at any par-

ticular phase of the moon. Statistics reveal no connection between the two events whatever, a result which common sense would lead us to expect.

Far Up and Far Down

Astronomers are interested in finding out what is deep down in the earth as well as what is far out in space, and it seems worth while to record here some statements of great depths which have recently been published.

The St. John del Rey gold mine in Brazil is the deepest in the world, the bottom being 6,726 ft. below the surface at the top of the shaft. In the Kolar gold mine in India one shaft is 6,140 feet deep. The Village Deep mine in South Africa goes to 6,100 ft. In the U.S. the deepest is the Tamarack No. 5 copper mine in the Lake Superior region, the shaft descending 5,308 feet. The temperature of the rock at the lowest level in the St. John del Rey mine is 117° Fahr. C. A. C.

MEETINGS OF THE SOCIETY

AT LONDON

April meeting.—The regular monthly meeting was held in the Physics Building, Western University, on Friday, April 13, at 8 p.m., Dr. Kingston presiding.

The address of the evening was "A Popular Presentation of the Einstein Theory of Relativity" by Professor R. C. Dearle, M.A., Ph.D., of Western University.

Dr. Dearle pointed out that there are two Theories of Relativity: (*a*) The Special and (*b*) the General. The Special Theory applies to objects or systems in uniform motion and rests on experiments. The theory that light is due to wave motion was accepted in preference to the corpuscular theory as propounded by Newton. The ether was invented as a necessary medium.

In 1886 Michelson and Morley made their celebrated experiment on the speed of light. A ray of light was divided into two parts; one half was sent forward and back in the direction towards which that part of the earth, where the experiment was made, was moving; the other half was sent back and forth across the line of this motion. The two rays of light following the different routes returned at the same instant. The light evidently travelled with a velocity independent of the earth's motion. Lorentz suggested that the arm of the instrument shortened a little as it was turned in line with the direction of the earth's motion. Einstein took Lorentz's idea and made it one of the fundamental principles of his new theory and deduced some startling conclusions. Dr. Dearle stated the two primary postulates given by Einstein, viz.:

1. All motion is relative.
2. The velocity of light is independent of the motion of its source.

Also his Principle of Equivalence which says "Every law of nature which holds good with respect to a system of co-ordinates K must also hold good for any other system K', provided K and K' are in uniform motion of translation." Einstein's theory clears up the ether-drift difficulty and explains the shifting of the orbit of Mercury which Newton's theory did not account for. It foretold the deflection of light by the sun's gravitational field, which was tested on the eclipse of 1919 and again in 1922 by the expedition which viewed the eclipse in Australia. By this last test Einstein's theory was again confirmed. Einstein also predicts the shifting of the lines of the solar spectrum towards the red end. This has not been established. Dr. Dearle gave a very lucid exposition of an admittedly difficult subject and his lecture was much appreciated.

May meeting.—An Observation Meeting was held on the Normal School grounds on Saturday, May 26. The weather was favourable, the attendance good and the result was a very successful meeting. Three large telescopes were used under the direction of Dr. Kingston, Dr. White and Mr. W. A. McKenzie. In addition there were two small telescopes and a number of field glasses. Observations were made of the Moon, the rings of Saturn, the Moons of Jupiter, some constellations and a number of multiple stars.

E. T. WHITE,
Secretary, London Centre.

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